

MERRIMACK RIVER BASIN
MARLBOROUGH, MASSACHUSETTS

WILLIAMS LAKE DAM

MA. 00451

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

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DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS. 02154

DECEMBER 1980

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) Williams Lake Dam is an earth embankment dam with a downstream rubble masonry wall. The dam is about 183 ft. long and 6 ft. high. The dam is small in size and has a hazard potential of high. Failure of the dam would flood Interstate Route I-495 and a housing development and possibly cause the loss of a few lives. The dam is judged to be in poor condition. At the time of inspection brush growth was evident on the embankment.		



DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02254

REPLY TO
ATTENTION OF:
NEDED-E

JUN 10 1981

Honorable Edward J. King
Governor of the Commonwealth of
Massachusetts
State House
Boston, Massachusetts

Dear Governor King:

Inclosed is a copy of the Williams Lake Dam (MA-00451) Phase I Inspection Report, which was prepared under the National Program for Inspection of Non-Federal Dams. The report is based upon a visual inspection, a review of past performance, and a preliminary hydrological analysis. A brief assessment is included at the beginning of the report.

The preliminary hydrologic analysis has indicated that the spillway capacity for the Williams Lake Dam would likely be exceeded by floods greater than 1.5 percent of the Probable Maximum Flood (PMF). Our screening criteria specifies that a dam of this class which does not have sufficient spillway capacity to discharge fifty percent of the PMF, should be adjudged as having a seriously inadequate spillway and the dam assessed as unsafe, non-emergency, until more detailed studies prove otherwise or corrective measures are completed.

The term "unsafe" applied to a dam because of an inadequate spillway does not indicate the same degree of emergency as that term would if applied because of structural deficiency. It does indicate, however, that a severe storm may cause overtopping and possible failure of the dam, with significant damage and potential loss of life downstream.

It is recommended that within twelve months from the date of this report the owner of the dam engage the services of a professional or consulting engineer to determine by more sophisticated methods and procedures the magnitude of the spillway deficiency. Based on this determination, appropriate remedial mitigating measures should be designed and completed within 24 months of this date of notification. In the interim a detailed emergency operation plan and warning system should be promptly developed. During periods of unusually heavy precipitation, round-the-clock surveillance should be provided.

JUN 10 1981

NEDED-E

Honorable Edward J. King

I have approved the report and support the findings and recommendations described in Section 7, with qualifications as noted above. I request that you keep me informed of the actions taken to implement these recommendations since this follow-up is an important part of the non-Federal Dam Inspection Program.

A copy of this report has been forwarded to the Department of Environmental Quality Engineering, the cooperating agency for the Commonwealth of Massachusetts. This report has also been furnished to the owner of the project, City of Marlborough, 860 Boston Post Road, Marlborough, Massachusetts 01752.

Copies of this report will be made available to the public, upon request to this office, under the Freedom of Information Act, thirty days from the date of this letter.

I wish to take this opportunity to thank you and the Department of Environmental Quality Engineering for the cooperation extended in carrying out this program.

Sincerely,

A handwritten signature in dark ink, appearing to read "C. E. Edgar, III". The signature is stylized with a large, sweeping initial "C" and a series of loops and strokes that form the rest of the name.

C. E. EDGAR, III
Colonel, Corps of Engineers
Commander and Division Engineer

WILLIAMS LAKE DAM

MA 00451

MERRIMACK RIVER BASIN
MARLBOROUGH, MASSACHUSETTS

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

NATIONAL DAM INSPECTION PROGRAM
PHASE I INSPECTION REPORT

Identification No.: MA 00451
Name of Dam: Williams Lake Dam
Town: Marlborough
County and State: Middlesex County, Massachusetts
Stream: Millham Brook
Date of Inspection: 21 October 1980

BRIEF ASSESSMENT

Williams Lake Dam is an earth embankment dam with a downstream rubble masonry wall. The dam is about 183 ft. long and 6 ft. high. At each abutment there is a saddle whose low point is about 1 ft. below the crest of the embankment. The upstream slope of the embankment is about 3 horizontal to 1 vertical and the crest width of the dam is about 20 ft. The spillway for the dam is located about 65 ft. left of the right abutment and it is constructed of granite blocks. It has a broadcrested weir which is 3.5 ft. long. The crest is located 2 ft. below the top of the embankment. There is no low level outlet for the facility. The dam is used to impound water for municipal water supply purposes on a reserve standby basis.

The lake is about 2,500 ft. long and the surface area of the lake is about 68 acres at spillway crest level. The drainage area above the dam is about 0.45 sq. mi. (288 acres). The maximum storage to top of the low points in the abutments is 320 acre-ft. The size classification is thus small. Failure of the dam would flood Interstate Route 495 and a housing development located about 1,300 ft. downstream of I-495 and possibly cause the loss of a few lives. Therefore, the dam has been classified as having a high hazard potential. Based on small size and high hazard, the range for the test flood is a $\frac{1}{2}$ probable maximum flood ($\frac{1}{2}$ PMF) to a full PMF. The selected test flood for the project is a $\frac{1}{2}$ PMF.

The test flood inflow is 860 CFS; the routed test flood outflow of 290 CFS would overtop the low points in the abutments by 1.2 ft. and the top of the dam by 0.2 ft. The spillway can pass about 10 CFS or about 3 percent of the routed test flood outflow without overtopping the low points in the abutments.

The dam is judged to be in poor condition. At the time of the inspection brush growth was evident on the embankment, the downstream rubble masonry wall and the spillway walls were deteriorated, and seepage was noted on the downstream side of the spillway.

Within one year after receipt of this Phase I Inspection Report, the owner, the City of Marlborough, should retain the services of a registered professional engineer and implement the results of his evaluation of the following: (1) perform a detailed hydrologic and hydraulic analysis to further assess the need for and means to increase the project discharge capacity; (2) evaluate the feasibility of raising the embankment and the saddles at the abutments; (3) design and construct a means to drain the lake; (4) investigate the seepage at the toe of the spillway; (5) develop a plan for phased removal of trees including their root system from the embankment and within 10 ft. of the downstream toe and back filling with suitable compacted material; and (6) investigate the adequacy of the riprap on the upstream slope of the dam.

The owner should also carry out the following operational and maintenance procedures: (1) replace the dislodged stone in the spillway channel; (2) repair the downstream masonry wall; (3) develop a formal surveillance and downstream emergency warning plan, including round-the-clock monitoring during periods of heavy precipitation; (4) institute procedures for an annual technical inspection of the dam and its appurtenant structures; (5) immediately remove all brush and debris from the dam and spillway, and within 10 ft. of the downstream toe; and (6) implement a regular periodic maintenance program.



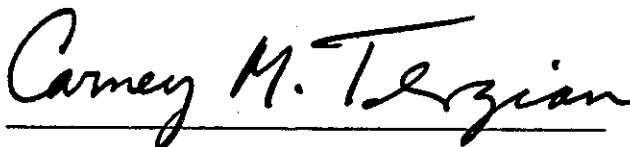
Peter B. Dyson
Project Manager



This Phase I Inspection Report on Williams Lake Dam has been reviewed by the undersigned Review Board members. In our opinion, the reported findings, conclusions, and recommendations are consistent with the Recommended Guidelines for Safety Inspection of Dams, and with good engineering judgement and practice, and is hereby submitted for approval.



ARAMAST MAHTESIAN, MEMBER
Geotechnical Engineering Branch
Engineering Division

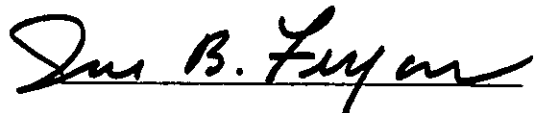


CARNEY M. TERZIAN, MEMBER
Design Branch
Engineering Division



JOSEPH W. FINEGAN, JR., CHAIRMAN
Water Control Branch
Engineering Division

APPROVAL RECOMMENDED:



JOE B. FRYAR
Chief, Engineering Division

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, sub-surface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test Flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the test flood should not be interpreted as necessarily posing a highly inadequate condition. The test flood provides a measure of relative spillway capacity and serves as an aide in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

The Phase I Investigation does not include an assessment of the need for fences, gates, no-trespassing signs, repairs to existing fences and railings and other items which may be needed to minimize trespass and provide greater security for the facility and safety to the public. An evaluation of the project for compliance with OSHA rules and regulations is also excluded.

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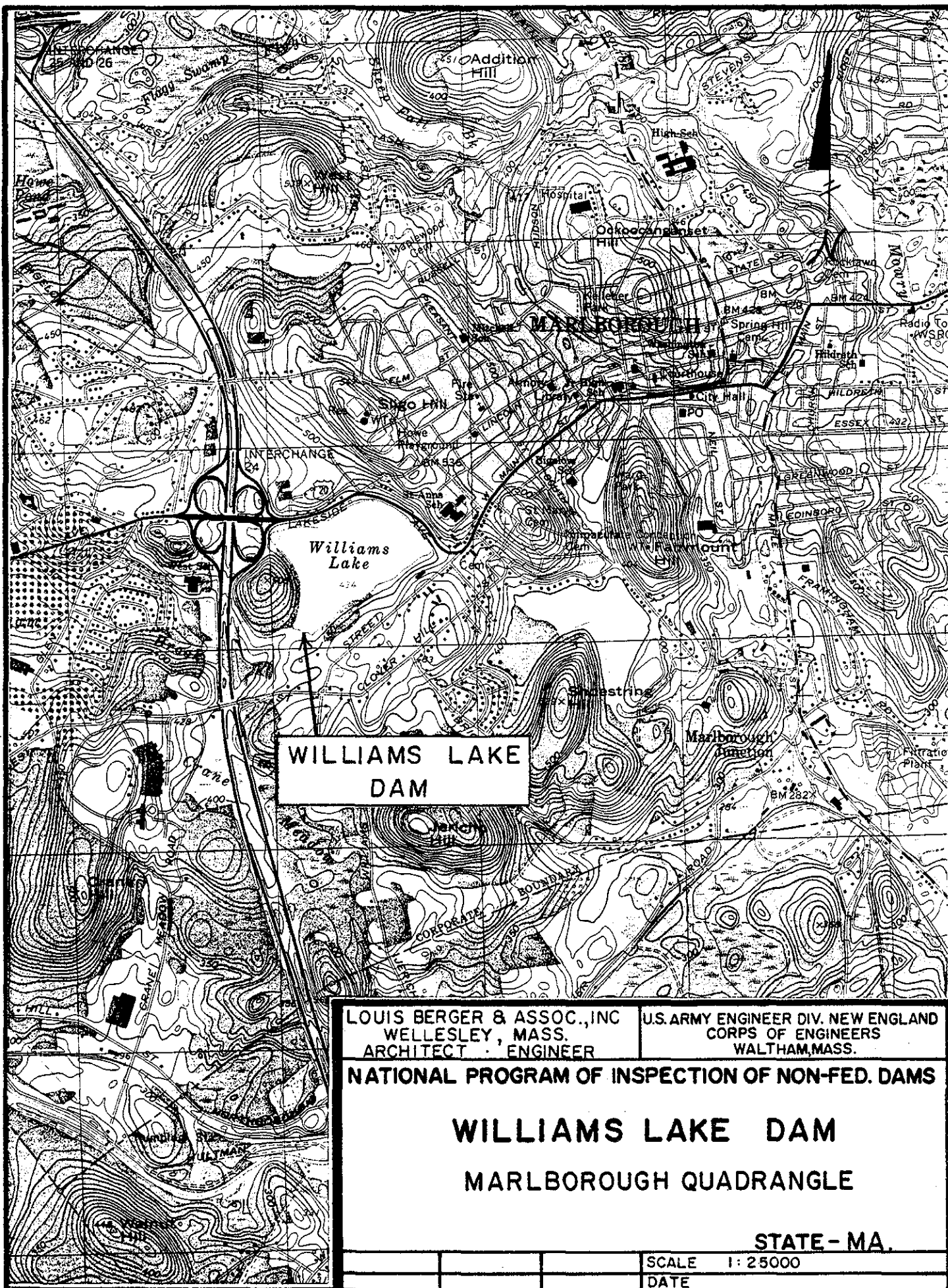
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WILLIAMS LAKE DAM



OVERVIEW PHOTOGRAPH



WILLIAMS LAKE
DAM

LOUIS BERGER & ASSOC., INC
WELLESLEY, MASS.
ARCHITECT · ENGINEER

U.S. ARMY ENGINEER DIV. NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

WILLIAMS LAKE DAM

MARLBOROUGH QUADRANGLE

STATE - MA.

SCALE 1:25000

DATE

PHASE I INSPECTION REPORT

WILLIAMS LAKE DAM MA 00451

SECTION 1 - PROJECT INFORMATION

1.1 General

a. Authority. Public Law 92-367, August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a national program of dam inspection throughout the United States. The New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England Region. Louis Berger & Associates, Inc. has been retained by the New England Division to inspect and report on selected dams in the State of Massachusetts. Authorization and notice to proceed was issued to Louis Berger & Associates, Inc. under a letter of 30 September 1980 from William E. Hodgson, Jr., Colonel, Corps of Engineers. Contract No. DACW33-80-C-0043, Job Change No. 1 has been assigned by the Corps of Engineers for this work.

b. Purpose of Inspection.

(1) Perform technical inspection and evaluation of non-Federal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by non-Federal interests.

(2) Encourage and assist the States to initiate quickly effective dam safety programs for non-Federal dams.

(3) Update, verify and complete the National Inventory of Dams.

1.2 Description of Project

a. Location. Williams Lake Dam is located in Middlesex County in the City of Marlborough in Eastern Massachusetts. The pond is situated at the headwaters of Millham Brook about 2.6 miles upstream of the confluence of Millham Brook and the Assabet River. The dam is reached via Williams St. and is shown on U.S.G.S. Quadrangle, Marlborough, Mass. with coordinates approximately at N 42° 20' 09", W71° 34' 17".

b. Description of Dam and Appurtenances

(1) Description of Dam. Williams Lake Dam is a 6 ft. high, 183 ft. long, earth embankment dam. The dam is constructed

across a shallow valley at the outlet of Williams Lake. The bottom of the lake is believed to be lower than the toe of the dam. A saddle is located at each abutment. The low point in the saddles are about 1 ft. below the crest of the dam. The saddle at the right abutment is about 55 ft. long and the saddle on the left abutment is about 72 ft. long. The upstream slope of the earth embankment is about 3 horizontal to 1 vertical and is covered with fieldstones ranging in size from 2 inches to 12 inches. The downstream face of the dam is formed by a nearly vertical rubble masonry wall built of rounded fieldstones generally from one to two feet in diameter. The wall has no mortar in the joints. The crest of the dam is about 20 ft. wide.

(2) Spillway. The spillway for Williams Lake Dam is located about 65 ft. left of the right abutment. The spillway is constructed of granite blocks and has a granite block broad-crested weir. The length of the weir is 3.5 ft. and its crest is located 2 ft. below the top of the earth embankment. Granite blocks form the training walls of the spillway and extend to the top of the earth embankment.

There is no low level outlet or other appurtenant structures at the dam.

c. Size Classification. Williams Pond Dam has a hydraulic height of about 6 ft. above downstream river level, and impounds a normal storage of about 250 acre-ft. to spillway crest level and a maximum of about 320 acre-ft. to top of the low points at the abutments.

In accordance with the capacity criteria given in Recommended Guidelines for Safety Inspection of Dams, the project falls into the small category on the basis of height and capacity and is therefore classified accordingly. A small size dam is one which has a height less than 25 ft. and a storage capacity greater than 50 ac.-ft. but less than 1,000 ac.-ft.

d. Hazard Classification. A breach failure of Williams Lake Dam would release water down Millham Brook for a distance of about 2.6 miles into the Assabet River. About 1,400 ft. below the dam Millham Brook passes under Interstate Route 495 through a 5 ft. dia. pipe culvert. It is estimated the initial breach discharge of 1,140 CFS will be only reduced to about 1,110 CFS at the I-495 crossing and the roadway will be overtopped by about 2 ft. of water. About 2,700 ft. below the dam Millham Brook flows into a closed drainage system which passes under a housing development for a distance of about 1,600 ft. The waterway opening at the entrance of this closed system is a 30 in. dia. pipe with little freeboard. It is estimated the breach discharge at this point will be about 1080 CFS and the breach flow will spill into the housing development flooding several streets and about 20 homes to a depth of about 2 ft. All of the

flooding of the homes is estimated to be at an elevation below sill elevation. It is estimated under the prefailure condition Interstate Route 495 will not be overtopped, but there will be flooding in the housing development streets to a depth of about 6 inches. In this area of initial impact is is considered there is the potential for appreciable economic loss and the possibility of the loss of a few lives. In accordance with the Recommended Guidelines for Safety Inspection of Dams, Williams Lake Dam has therefore been classified as having a high hazard potential.

e. Ownership. Williams Lake Dam is owned by the City of Marlborough, 860 Boston Post Road, Marlborough MA 01752. Telephone: 617-485-1755.

f. Operator. Mr. John Hartley, City of Marlborough, East Waste Water Treatment Plant, 860 Boston Post Road, Marlborough, MA 01752, Telephone: 617-485-1755.

g. Purpose of Dam. The dam impounds a body of water used as a municipal water supply for the City of Marlborough, MA. on a reserve standby basis. Water is pumped from the lake to a treatment plant and then distributed throughout the City.

h. Design and Construction History. It is not known by whom the dam was designed or constructed. It is believed the dam was constructed in 1882 to increase the impoundment capacity of Williams Lake.

i. Normal Operating Procedures. There is no low level outlet for the dam, nor is the spillway equipped with stoplogs or flashboards. According to the owner's representative the dam is visited about once per year by City personnel.

1.3 Pertinent Data

a. Drainage Area. The drainage area contributing to Williams Lake is situated at the headwaters of Millham Brook which is tributary to the Assabet River. The drainage area encompasses a total of about 0.45 sq. mi. (288 acres). The lake has a surface area of 68 acres. The longest circuitous water course leading to the dam is about 5,000 ft. long with an elevation difference of about 116 ft., or at a slope of about 122 ft. per mile. The drainage area has a length of about 5,000 ft. and an average width of about 2,500 ft. The basin consists predominately of open fields with a heavily developed urban area in the northeast sector. Part of the Route 495 and Route 20 interchange is located in the western sector of the drainage area.

b. Discharge at Damsite

(1) Outlet Works Conduit. There is no low level outlet at the dam.

(2) Maximum Known Flood at Damsite. No records are available of flood inflows into Williams Lake, nor of spillway releases and surcharge heads during such inflows.

(3) Ungated Spillway Capacity at Top of Dam. The ungated spillway capacity is 10 CFS when the water level is at the low points in the saddles at the left and right abutments, elev. 435 and 15 CFS when the water level is at elev. 436.

(4) Ungated Spillway Capacity at Test Flood Elevation. The ungated spillway capacity at test flood elevation 436.2 is 34 CFS.

(5) Gated Spillway Capacity at Normal Pool Elevation. Not applicable.

(6) Gated Spillway Capacity at Test Flood Elevation. Not applicable

(7) Total Spillway Capacity at Test Flood Elevation. The total spillway discharge at the test flood elevation is the same as (4) above, 34 cfs at test flood elevation 436.2.

(8) Total Project Discharge at Top of Dam. The total project discharge is the same as (3) above 10 CFS when the water surface level is at the low points in the saddles at the left and right abutment, elev. 435, and 190 CFS when the water level is at top of dam elev. 436.

(9) Total Project Discharge at Test Flood Elevation. The total project discharge at test flood is 290 cfs at elevation 436.2.

c. Elevation (ft. N.G.V.D.)

- (1) Streambed at toe of dam - 430.0
- (2) Bottom of cutoff - Unknown
- (3) Maximum tailwater - Unknown
- (4) Normal pool - 434.0
- (5) Full flood control pool - Not applicable
- (6) Spillway crest - 434.0
- (7) Design surcharge (Original Design) - Unknown
- (8) Top of dam - 436.0
- (9) Low point in saddles - 435.0 ±
- (10) Test flood surcharge - 436.2

d. Reservoir (Length in feet)

- (1) Normal pool - 2,500
- (2) Flood control pool - Not applicable
- (3) Spillway crest pool - 2,500
- (4) Top of dam - 2,500
- (5) Test flood pool - 2,500

e. Storage (acre-ft.)

- (1) Normal pool -250
- (2) Flood control pool - Not applicable
- (3) Spillway crest pool - 250
- (4) Low point in saddles - 320
- (5) Top of dam - 390
- (6) Test flood pool -405

f. Reservoir Surface (acres)

- (1) Normal pool - 68
- (2) Flood-control pool - Not applicable
- (3) Spillway crest - 68
- (4) Low point in saddles - 69.7
- (5) Top of dam - 71.6
- (6) Test flood pool - 71.9

g. Dam

- (1) Type - Stone wall with upstream earth embankment
- (2) Length - 183 ft.
- (3) Height - 6 ft.
- (4) Top width - 20 ft.
- (5) Side slopes - Downstream: vertical
Upstream: 3 horizontal to 1 vertical
- (6) Zoning - Unknown

- (7) Impervious core - Unknown
- (8) Cutoff - Unknown
- (9) Grout curtain - Unknown
- h. Diversion and Regulating Tunnel - Not applicable
- i. Spillway
 - (1) Type - Broadcrested, granite block
 - (2) Length of weir - 3.5 ft.
 - (3) Crest elevation - 434.0
 - (4) Gates - None
 - (5) U/S Channel - Short granite block channel
 - (6) D/S Channel - Natural channel in earth
- j. Regulating Outlets - Not applicable

SECTION 2 - ENGINEERING DATA

2.1 Design Data

No data on the design of the dam or appurtenances was available. In the course of the inspection, measurements were taken and a sketch plan and profile layout of Williams Lake Dam has been prepared, and is included in Appendix B.

2.2 Construction Data

No records or correspondence have been found regarding construction data.

2.3 Operation Data

No engineering operational data were disclosed.

2.4 Evaluation of Data

a. Availability. There was no engineering data available. The basis of the evaluation presented in this report is principally the visual observations of the inspection team.

b. Adequacy. The lack of in-depth engineering data did not allow for a definitive review. Therefore, the adequacy of this dam could not be assessed from the standpoint of reviewing design and construction data, but is based primarily on visual inspection, past performance history and sound engineering judgement.

c. Validity. Not applicable.

SECTION 3 - VISUAL INSPECTION

3.1 Findings

a. General. The visual inspection of Williams Lake Dam took place on 21 October 1980. On that date the water level in the lake was about 2.3 ft. below the crest of the spillway. Though no flow was passing over the spillway, seepage was noted at the downstream toe of the spillway and the stream bed just below the dam was wet. The spillway was in need of repair and brush and tree growth on the embankment was abundant. In general the dam was judged to be in poor physical condition.

b. Dam. Williams Lake Dam is an earth embankment structure with a downstream rubble masonry wall with uncemented joints constructed of field stones ranging in size from 1 to 2 ft. in diameter. The upstream slope of the dam is about 3 horizontal to 1 vertical and is covered with fieldstones generally from 1 to 2 ft. in diameter. The crest width of the embankment is about 20 ft. There are saddles at each abutment which have low points that are about 1 ft. lower than the crest of the dam. The saddle at the right abutment is about 55 ft. long and the saddle at the left abutment is about 72 ft. long.

Abundant brush and tree growth extends along the entire length of the dam. (see Appendix C, Photo Nos. 1 & 2). The downstream stone wall is tilting in the downstream direction and a section of the wall has moved outward and is essentially demolished (see Appendix C, Photo Nos. 3 & 4). At the time of the inspection, there was no seepage observed along the downstream toe of the wall area. The upstream slope of the dam is irregular and overgrown with trees. The crest of the dam shows signs of trespassing as there is a footpath which passes along the entire length of the dam.

c. Appurtenant Structures. The spillway for the dam is located about 65 ft. left of the right abutment. It is of granite block construction and has a broadcrested wier which is 3.5 ft. long. The training walls are constructed of granite and extend 2 ft. above the spillway crest to the top of the embankment. The spillway is in poor condition, shows no sign of recent maintenance and is full of debris. A granite block has dislodged from the right spillway training wall and has fallen into the spillway channel. Debris has collected downstream of the weir (see Appendix C Photo No. 5). Though no seepage was noted downstream of the embankment area, a minor amount of clear seepage, estimated to be less than 1 gpm, was issuing through and beneath the spillway.

There is no low level outlet at the dam or other appurtenant structures.

d. Reservoir Area. The shorelines upstream of the dam on both the right and left abutments appear stable with no evidence of landslides or sloughing. U. S. Route 20 passes along the northern rim of the lake and a pumping station used to pump water from the lake is located on the northern rim.

e. Downstream Channel. The spillway discharges into a small brook known as Millham Brook which joins the Assabet River about 2.6 miles below the dam. About 1,400 ft. below the dam the brook flows under Interstate Route 495 through a 5 ft. dia. concrete pipe. About 2,700 ft. below the dam the conveyance capacity of the brook becomes severely restricted as the brook flows under a housing development and through a closed drainage system for a distance of about 1,600 ft. At the entrance of the closed system there is a 30 in. dia. pipe with very little allowable headwater height. About 1.4 miles below the housing development the brook enters the Millham Reservoir which has a surface area about equal to that of Williams Lake. About 400 ft. downstream of the Millham Reservoir flows enter the the Assabet River.

3.2 Evaluation

The visual inspection adequately revealed key characteristics of the dam as they may relate to its stability and integrity. The dam and appurtenant works were judged to be in poor physical condition. There is heavy brush and tree growth on the dam. The spillway is in a deteriorated condition and the downstream rubble masonry wall has also deteriorated. Minor seepage was noted at the toe of the spillway. There is no low level outlet for the facility and there is no regular periodic maintenance program for the dam.

SECTION 4 - OPERATIONAL AND MAINTENANCE PROCEDURES

4.1 Operation Procedures

a. General. The dam is owned and operated by the City of Marlborough. It is used to impound water for municipal water supply purposes. Water is pumped from the lake through a pumping station located on the north shore of the lake. There is no low level outlet at the facility and the spillway has no controls, stoplogs or flashboards. The dam is visited about once per year.

b. Description of any Warning System in Effect. No warning system is in effect at Williams Lake.

4.2 Maintenance Procedures

a. General. There is no documented regular periodic maintenance program in effect at Williams Lake Dam. There are, however, several items which require periodic maintenance, such as: the removal of debris from the crest of the spillway; the repair of the spillway training walls; the removal of trees and brush from the earth embankment; and the surveillance of the downstream wall regarding seeps.

b. Operating Facilities. There are no operating facilities at the dam.

4.3 Evaluation

Overall maintenance of the dam is generally poor. Specific maintenance items are evaluated as follows: Brush and tree growth has not been cleared on the embankment; the spillway is in a deteriorated condition; the downstream rubble masonry wall is deteriorating; and the spillway had not been cleared of debris. A regular periodic maintenance program should be implemented. The owner should also establish a formal downstream warning system for the dam in the event of an emergency.

SECTION 5 - EVALUATION OF HYDRAULIC/HYDROLOGIC FEATURES

5.1 General.

Williams Lake Dam is a rubble faced stone wall dam with an upstream earth embankment. There are saddles in the natural ground at each abutment which are about 1 ft. lower than the crest of the embankment. The dam impounds a normal storage of about 250 acre-ft. with provisions for an additional 69 acre-ft. in its surcharge space to the low point in the saddles and 140 acre-ft. in its surcharge space to the top of the earth embankment. The dam is basically a low surcharge-low spillage facility used to impound water for municipal water supply purposes on a reserve standby basis. The depth of the lake is reported to be about 10 ft. which would indicate there was a smaller natural impoundment at the site prior to the time the dam was built. With the lake water surface level at the top of the earth embankment the spillway discharges about 30 CFS. With the water level at that elevation a total of about 150 CFS would be spilling through the saddles at the abutments.

The general characteristics of the 0.45 sq. mi. (288 acres) drainage area is best described as rolling terrain, which rises from elevation 434 at spillway crest level to elevation 590. The drainage area predominately consists of open fields but there is a heavily urbanized area in the northeast sector.

5.2 Design Data

No hydrologic computations or hydraulic data has been recovered for the dam.

5.3 Experience Data

No records are available in regard to past operation of the reservoir, nor of surcharge encroachments and flows through the spillway. The maximum past outflows are unknown. It was reported by the owner's representatives that to their knowledge the dam had never been overtopped.

5.4 Test Flood Analysis

Hydrologic characteristics of Williams Lake Dam and drainage area were evaluated in accordance with criteria given in Recommended Guidelines for Safety Inspection of Dams. As indicated in Section 1.2, paragraphs c and d, Williams Lake Dam is classified as small in size with a high hazard potential. The recommended test flood for hydraulic evaluation of such a dam ranges from a half probable maximum flood, ($\frac{1}{2}$ PMF) to a full PMF. Because a housing development is located about 2,700 ft. downstream a test flood equal to a $\frac{1}{2}$ PMF was selected.

Precipitation data was obtained from Hydrometeorological Report NO. 51, which for this area of Massachusetts is about 25 in. of 6 hour maximum rainfall over a 10 square mile area. This value was then reduced by 20 percent to allow for basin size, shape and fit factors and further reduced by 0.4 in. for infiltration losses. The six hour rainfall was distributed into one hour incremental periods as suggested in the Corps of Engineer's Publication EC 1110-2-1411.

A triangular incremental unitgraph was assumed for the inflow hydrographs, using a computed lag time value of 1.74 hours to derive a time-to-peak for a triangular hydrograph of 1.84 hours (see computations on Sheets D-6 thru D-8, Appendix D). A PMF inflow hydrograph is shown on Sheets D-9, Appendix D, indicating a peak inflow of about 1,720 cfs or a CSM of about 3,800. The peak inflow was divided by two to arrive at the test flood inflow value of 860 cfs.

Discharge tables and curves for the spillway and for over the top of the dam are shown on Sheets D-4 and D-5, Appendix D. For determining surface areas and surcharge capacities, planimetered areas were taken from contours delineated on 1:24,000 U.S.G.S. sheets.

A flood routing was performed for the test flood. Though the water surface level in the lake was 2.3 ft. below the spillway crest on the day of the inspection, for the purpose of this analysis the water surface was assumed to be at the spillway crest at the start of the routing. The results of this routing are shown on sheets D-11 thru D-12, Appendix D, and are summarized as follows:

<u>Test Flood Magnitude</u>	<u>Maximum Inflow cfs</u>	<u>Max. Res. Elev.</u>	<u>Maximum Head Over Embankment</u>	<u>Max. Head Over Low Point Lt. Rt. Abuts.</u>	<u>Max. Routed Test Flood Outflow cfs</u>
½ PMF	860	436.2 ft.	0.2 ft.	1.2 ft.	290

From the above table, it can be seen that the project will not pass the routed test flood outflow without overtopping the low point at the left and right abutments by 1.2 ft. and the crest of the dam by 0.2 ft. The spillway can only handle about 3 percent of the routed test flood without overtopping the low points in the left and right abutment.

5.5 Dam Failure Analysis.

A breach owing to structural failure of the dam by piping or sloughing is a possibility. For this analysis a breach was assumed with the water level in the lake at the crest of the embankment.

The "rule of thumb" method suggested in the New England Division Corps of Engineers March 1978 Guidance Report was used for the breach analysis. With a breach width of 40 percent of the embankment length at mid height equal to 40 ft., an outflow of about 1,140 CFS, which includes 30 CFS through the spillway and 150 CFS through the saddles would be realized, (see sheets D-13 thru D-17, Appendix D).

The breach outflows from the dam will flow down Millham Brook to the Assabet River located about 2.6 miles downstream. In the 1,400 ft. reach below the dam the outflow travels along a small brook channel to a 5 ft. dia. pipe culvert located under Interstate Route 495. It is estimated the breach discharge will only be reduced to about 1100 CFS at this point and I-495 will be overtopped by about 2 ft. of water. Under the prefailure conditions it is estimated the I-495 culvert will pass the pre-failure flows without overtopping the roadway. About 1,300 ft. beyond Interstate Route 495 Millham Brook enters into a closed drainage system as it passes under part of a housing development for a distance of about 1,600 ft. The entrance to the closed drainage system is a 30 in. circular pipe with very little freeboard. It is estimated the breach discharge will flow through the housing development flooding streets and about 20 houses to depths of 2 ft. It is estimated the flooding of all homes will be confined to below sill elevations resulting in only basement flooding. For the prefailure conditions it is estimated there will be street flooding to depths of about six inches. It is estimated there will be no further significant flooding beyond the housing development. About 1.3 miles below the housing development the brook enters Millham Reservoir and shortly thereafter the Assabet River.

In summary it is estimated a breach of the dam could cause appreciable economic losses, therefore, in accordance with the Recommended Guidelines for Safety Inspection of Dams the dam has been classified as having a high hazard potential. Sheet D-18, Appendix D, shows the area of initial impact.

SECTION 6 - EVALUATION OF STRUCTURAL STABILITY

6.1 Visual Observations

The Lake Williams Dam is in poor condition at the present time as revealed by the field inspection of October 21, 1980. There are several items of a remedial nature which were observed during the field visit and which will require treatment as outlined in Section 7. There are also deficiencies of a potentially more serious nature which will require the services of a registered professional engineer as outlined in Section 7.

6.2 Design and Construction Data

No definitive plans of the embankment, spillway, and rubble masonry wall are available. Data on the physical characteristics of the embankment materials are lacking. Calculations pertaining to the stability of the rubble masonry wall are lacking.

6.3 Postconstruction Changes

There are no records of any postconstruction changes made to the dam or the spillway over the course of its history.

6.4 Seismic Stability

The dam is in seismic zone number 2 and, in accordance with recommended Phase I guidelines, does not warrant seismic analysis.

SECTION 7

ASSESSMENT, RECOMMENDATIONS AND REMEDIAL MEASURES

7.1 Dam Assessment

a. Condition. On the basis of the Phase I visual examination, Williams Lake Dam is judged to be in poor condition. The deficiencies reveal that further investigations should be carried out and some remedial work is needed. The major concerns revealed by the Phase I investigation are that the spillway will only pass about 3 percent of the routed test flood without overtopping the low points in the abutments and that there is no low level outlet for the facility.

b. Adequacy of Information. The lack of in-depth engineering data did not allow for a definitive review. Therefore, the adequacy of this dam could not be assessed from the standpoint of reviewing design and construction data, but is based primarily on visual inspection, past performance history and sound engineering judgement.

c. Urgency. The recommendations and remedial measures enumerated below should be implemented by the owner within one year after receipt of this Phase I Inspection Report.

7.2 Recommendations

It is recommended that the owner, the City of Marlborough, should retain the services of a registered professional engineer experienced in the design of dams to make a thorough study of the following, and if proved necessary, appropriate remedial works should be designed and constructed:

(1) Perform a detailed hydrologic and hydraulic analysis to further assess the need for a means to increase the project discharge capacity.

(2) Determine the feasibility of raising the embankment and the low sections at the abutments to such elevation as may be determined from the study in (1) above.

(3) Design and construct a means to drain the lake.

(4) Investigate the seepage through and beneath the spillway.

(5) Because of their proximity to the downstream masonry wall, develop a plan for phased removal of trees and brush growth including their root systems from the embankment and within 10 ft. of the downstream toe and backfilling with suitable compacted material.

(6) Investigate the adequacy of the riprap on the upstream slope.

7.3 Remedial Measures

a. Operation and Maintenance Measures

(1) Replace the dislodged stone in the spillway channel.

(2) Repair the downstream rubble masonry walls.

(3) Develop an "Emergency Action Plan" that will include an effective preplanned downstream warning system, locations of emergency equipment, materials and manpower, authorities to contact and potential areas that require evacuation. The plan will also include round-the-clock monitoring of the project during periods of heavy precipitation.

(4) Institute procedures for an annual technical inspection of the dam and its appurtenant structures.

(5) Immediately remove all brush and debris from dam and spillway, and within 10 ft. of downstream toe.

(6) Implement a regular periodic maintenance program.

7.4 Alternatives

There are no feasible alternatives to the above recommendations.

Appendix A
Inspection Checklist

VISUAL INSPECTION CHECKLIST
PARTY ORGANIZATION

PROJECT Williams Lake Dam DATE 21 October 1980
OWNER City of Marlborough, MA TIME 1:30 PM
WEATHER Misty/Cool
W.S. ELEV. 431.7 U.S. DN.S.

INSPECTION PARTY

A/E REPRESENTATIVES

OWNER'S REPRESENTATIVES

- | | |
|-----------------------------|--------------------------|
| 1. <u>Pasquale Corsetti</u> | 6. <u>Roscoe Cheney</u> |
| 2. <u>William Zoino</u> | 7. <u>Philip Maurice</u> |
| 3. <u>Carl Hoffman</u> | 8. _____ |
| 4. <u>Roger Berry</u> | 9. _____ |
| 5. _____ | 10. _____ |

PROJECT FEATURE	INSPECTED BY	REMARKS
1. <u>Hydrology</u>	<u>Roger Berry</u>	<u>LBA</u>
2. <u>Hydraulics/Structures</u>	<u>Carl Hoffman</u>	<u>LBA</u>
3. <u>Geotechnical</u>	<u>William Zoino</u>	<u>GZA</u>
4. <u>General Features</u>	<u>Pasquale Corsetti</u>	<u>LBA</u>
5. _____	_____	_____
6. _____	_____	_____
7. _____	_____	_____
8. _____	_____	_____
9. _____	_____	_____
10. _____	_____	_____

LBA - Louis Berger & Associates, Inc.
GZA - Goldberg-Zoino & Associates, Inc.

PERIODIC INSPECTION CHECKLIST

PROJECT Lake Williams Dam DATE 21 October 1980
 PROJECT FEATURE Embankment NAME W. S. Zoino
 DISCIPLINE Geotechnical NAME _____

AREA EVALUATED	CONDITIONS
<u>DIKE EMBANKMENT</u>	
Crest Elevation	436
Current Pool Elevation	2.3' below spillway crest
Maximum Impoundment to Date	Unknown
Surface Cracks	None
Pavement Condition	N/A
Movement or Settlement of Crest	None
Lateral Movement	Downstream rubble wall tilting downstream
Vertical Alignment	Irregular
Horizontal Alignment	Poor - tilting wall
Condition at Abutment and at Concrete Structures	Poor - spillway training walls partially dislodged
Indications of Movement of Structural Items on Slopes	Downstream rubble wall locally dislodged
Trespassing on Slopes	Minor
Vegetation of Slopes	Very heavy both up and downstream
Sloughing or Erosion of Slopes or Abutments	None
Rock Slop Protection - Riprap Failures	Fair, small size 2" to 12"
Unusual Movement or Cracking at or near Toes	None
Unusual Embankment or Downstream Seepage	Minor seepage below spillway less than 1 GPM
Piping or Boils	None
Foundation Drainage Features	None
Toe Drains	None
Instrumentation System	None

PERIODIC INSPECTION CHECKLIST

PROJECT Williams Lake Dam DATE 21 October 1980
 PROJECT FEATURE Spillway NAME _____
 DISCIPLINE Hydraulics/Structures NAME Carl Hoffman

AREA EVALUATED	CONDITIONS
<u>OUTLET WORKS - SPILLWAY WEIR, APPROACH AND DISCHARGE CHANNELS</u>	
a. Approach Channel	
General Condition	Poor
Loose Rock Overhanging Channel	Granite blocks loose
Trees Overhanging Channel	Yes
Floor of Approach Channel	Irregular granite blocks
b. Weir and Training Walls	
General Condition of Concrete	Granite blocks construction (poor)
Rust or Staining	N/A
Spalling	N/A
Any Visible Reinforcing	N/A
Any Seepage or Efflorescence	Seepage at downstream toe
Drain Holes	N/A
c. Discharge Channel	
General Condition	Fair
Loose Rock Overhanging Channel	No
Trees Overhanging Channel	Yes
Floor of Channel	Natural ground
Other Obstructions	

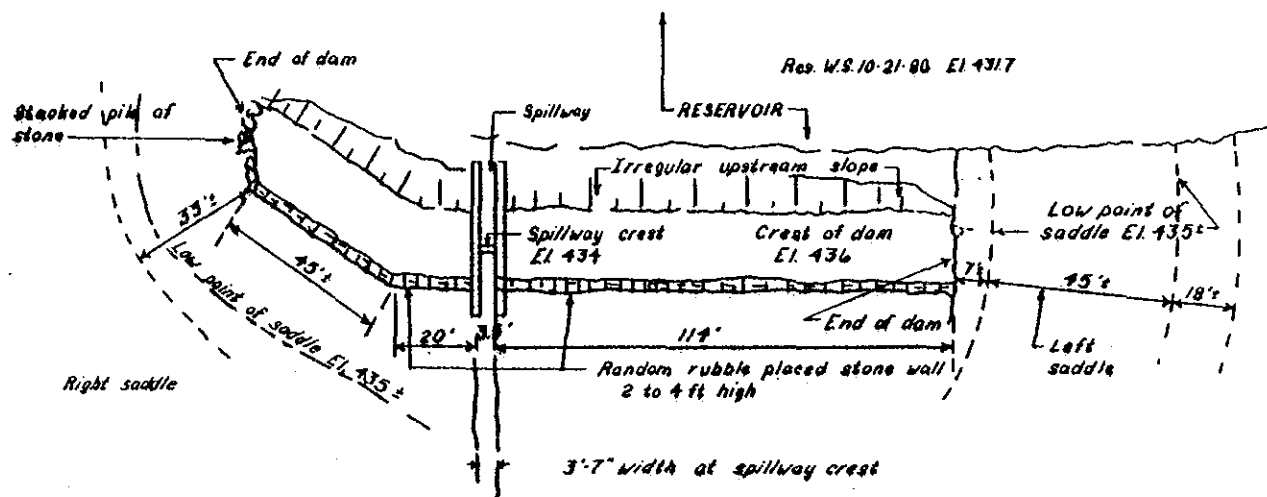
PERIODIC INSPECTION CHECKLIST

PROJECT Williams Lake Dam DATE 21 October 1980
 PROJECT FEATURE _____ NAME _____
 DISCIPLINE _____ NAME _____

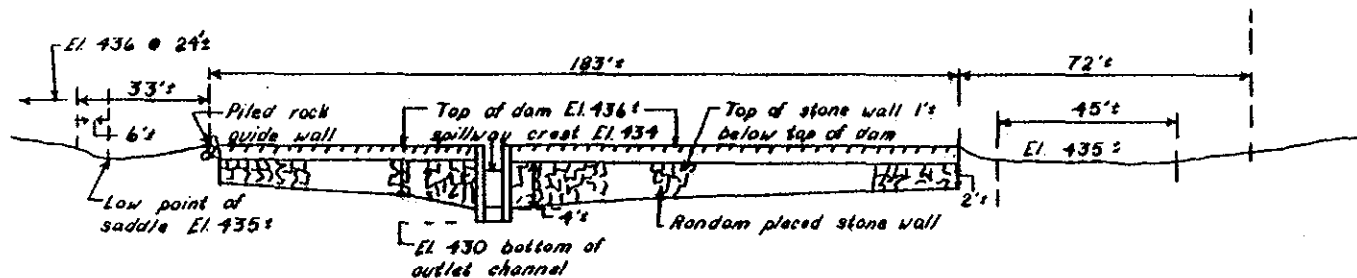
AREA EVALUATED	CONDITIONS
----------------	------------

Dike Embankment	N/A
Outlet Works - Intake Channel and Intake Structure	N/A
Outlet Works - Transition and Conduit	N/A
Outlet Works - Control Tower	N/A
Outlet Works - Service Bridge	N/A

Appendix B
Engineering Data



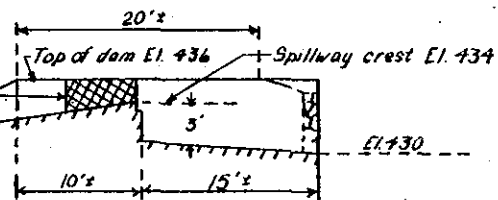
PLAN



PROFILE ALONG DAM CREST

Note: Right wall granite block displaced and lying in channel. Stone missing in left wall above crest level.

WS EL 431.7 (10-21-80)



SECTION THRU SPILLWAY

WILLIAMS LAKE DAM
MARLBOROUGH
PLAN AND PROFILES

7

INSPECTION REPORT - DAMS AND RESERVOIRS

(1.) Location: City/Town MARLBOROUGH

Dam No. 4-9-170-6

Name of Dam LAKE WILLIAMS DAM

Inspected by A. Z. PIZAN

F. H. PARE
Date of Inspection 7-25-77

(2) Owners: per: Assessors ☒ Prev. Inspection ☐

Reg. of Deeds ☐ Pers. Contact ☐

1. CITY OF MARLBOROUGH, DEPT. PUBL. WKS, NEIL ST. 485-0392

Name	St. & No.	City/Town	State	Tel. No.
		<u>MARLBORO, MASS.</u>	<u>01752</u>	

2.
Name St. & No. City/Town State Tel. No.

3.
Name St. & No. City/Town State Tel. No.

(3) Caretaker: (if any) e.g. superintendent, plant manager, appointed by absentee owner, appointed by multi owners.

SAME

Name	St. & No.	City/Town	State	Tel. No.
------	-----------	-----------	-------	----------

(4) No. of Pictures taken NONE

(5) Degree of Hazard: (if dam should fail completely)*

1. Minor ☒ 2. Moderate ☐

3. Severe ☐ 4. Disastrous ☐

*This rating may change as land use changes (future development)

(6) Outlet Control: Automatic ☐ Manual ☒

Operative ☒ yes: ☐ no.

Comments: FLASHBOARDS CONTROLLED WHEN NECESSARY.

(7) Upstream Face of Dam: Condition:

1. Good ☒ 2. Minor Repairs ☐

3. Major Repairs ☐ 4. Urgent Repairs ☐

Comments:

(8) Downstream Face of Dam: Condition: 1. Good ☒ 2. Minor Repairs _____
3. Major Repairs _____ Urgent Repairs _____

Comments: _____

(9) Emergency Spillway: Condition: 1. Good ☒ 2. Minor Repairs _____
3. Major Repairs _____ 4. Urgent Repairs _____

Comments: _____

(10) Water level @ time of inspection 2 ft. above _____ below ☒
top of dam _____ Principal spillway ☒
other _____

(11) Summary of Deficiencies Noted:

Growth (Trees and Brush) on Embankment BRUSH ON EMBANKMENT
Animal Burrows and Washouts _____
Damage to slopes or top of dam _____
Cracked or Damaged Masonry _____
Evidence of Seepage _____
Evidence of Piping _____
Erosion _____
Leaks _____
Grass and/or debris impeding flow _____
Clogged or blocked spillway _____
Other _____

4-9-170-6

-3-

(12) Remarks & Recommendations: (Fully Explain)

DAM IS IN GOOD CONDITION.

(13) Overall Condition:

1. Safe ☒

2. Minor repairs needed ☐

3. Conditionally safe - major repairs needed ☐

4. Unsafe ☐

5. Reservoir impounded no longer exists (explain)

Recommend removal from inspection list ☐

DESCRIPTION OF DAM
DISTRICT #4

Submitted by FRANCIS H. PARE & ADAM Z. PIZANO Dam No. 4-9-170-6
Date _____ City/Town MARLBOROUGH 01752
Name of Dam LAKE WILLIAM'S DAM

1. Location: Topo Sheet No. 23-D
Provide 8 1/2" x 11" in clear copy of topo map with location of Dam clearly indicated.
2. Year built: 1882 Year/s of subsequent repairs UNKNOWN
3. Purpose of Dam: Water Supply ☒ Recreational _____
Irrigation _____ Other _____
4. Drainage Area: 1 SQ. MI. 640 ACRES.
5. Normal Ponding Area: 72 acres; Ave. Depth 10'
impoundment: 240 MIL gals; 720 acre ft.
6. No. and type of dwellings located adjacent to pond or reservoir
i.e. summer homes etc. NONE
7. Dimensions of Dam: Length 195' Max. Height 5'
Slopes: Upstream Face 3:1
Downstream Face 2:1
Width across top 30
8. Classifications of Dam by Materials:
Earth ☒ Cone. Masonary ☒ Stone Masonary ☒
Timber _____ Rockfill _____ Other _____
9. A. Description of present land usage downstream of dam: 80% rural;
20% urban
B. Is there a storage area or flood plain downstream of dam which could accommodate the impoundment in the event of a complete dam failure?
no ☒ yes _____

DAM NO. 4-9-170-6

10.

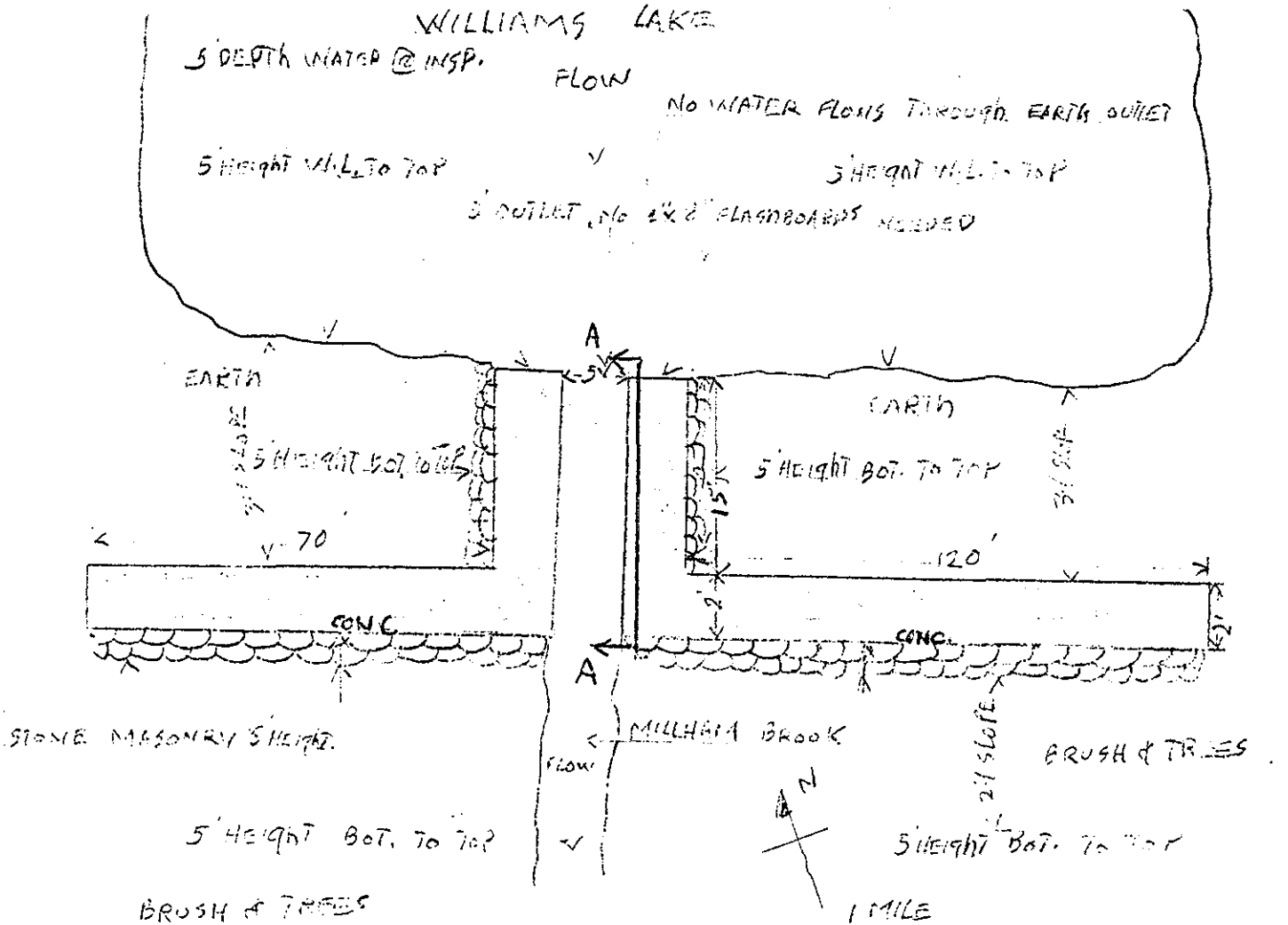
Risk to life and property in event of complete failure.

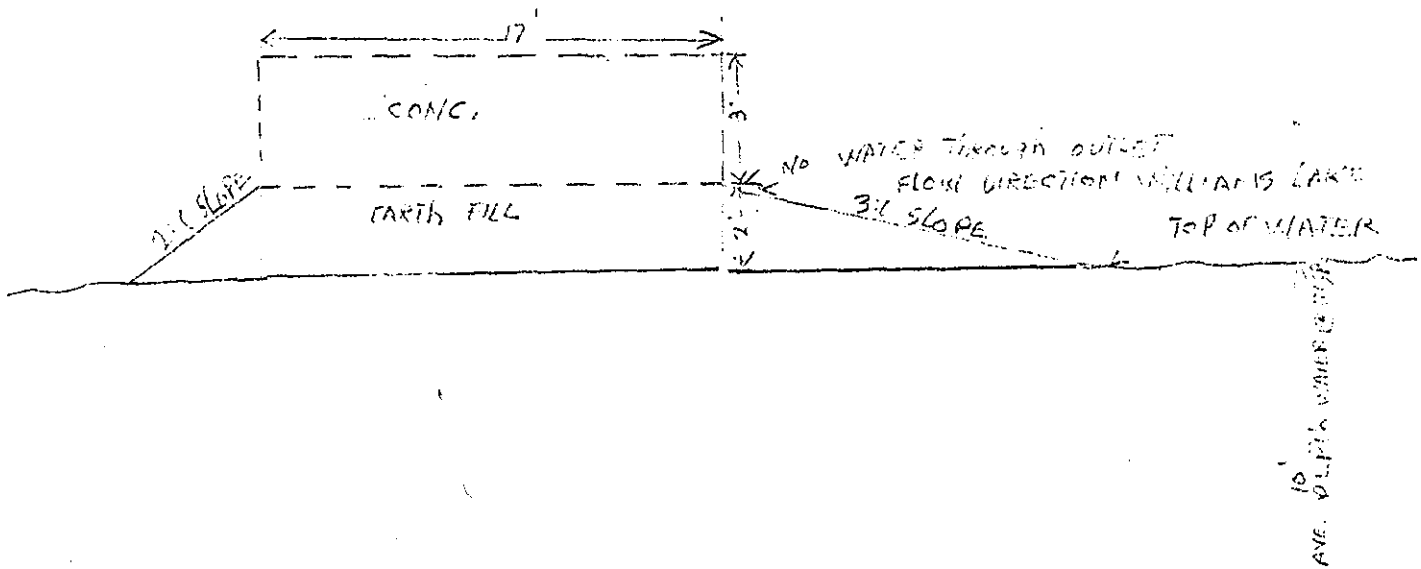
No. of people NONE
No. of homes 0
No. of businesses 11
No. of industries 11
No. of utilities 11
Railroads NONE
Other dams 11
Other _____

Type _____
Type _____

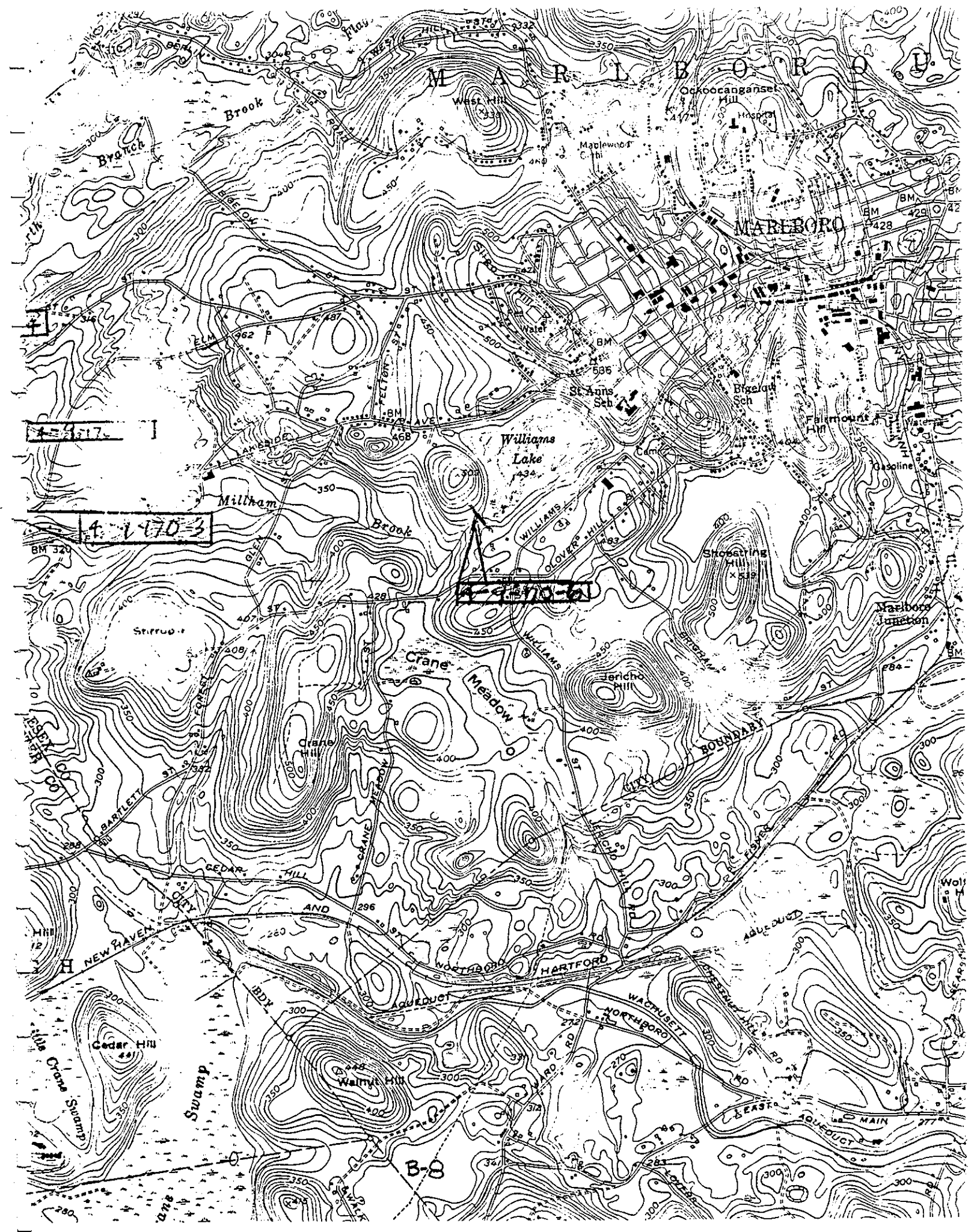
11.

Attach sketch of dam to this form showing section and plan 8 1/2" x 11" Sheet.



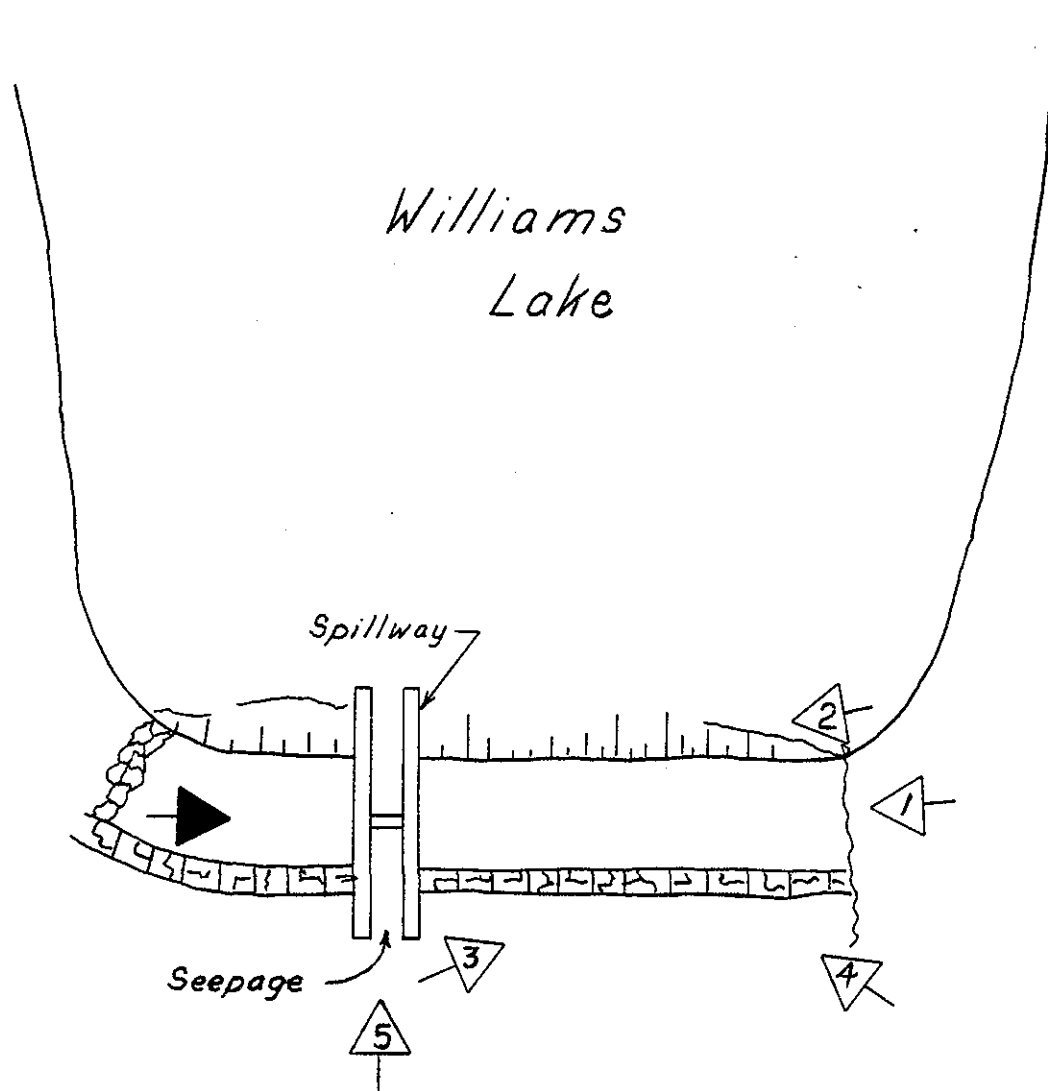


X SECTION AA
 SKETCH NOT TO SCALE



Appendix C

Photos



Overview Photo



Appendix "C" Photo

C-1

LOUIS BERGER & ASSOC., INC WELLESLEY, MASS. ARCHITECT · ENGINEER		U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.	
NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS			
WILLIAMS LAKE DAM			
SKETCH PLAN SHOWING LOCATION & ORIENTATION OF PHOTOS			
STATE - MA.			
		SCALE NOT TO SCALE	
		DATE	

WILLIAMS LAKE DAM



1. Brush and tree growth along crest of dam.



2. Brush and tree growth on upstream slope.

WILLIAMS LAKE DAM



3. View of deteriorated downstream stone wall from right abutment.



4. View of deteriorated downstream stone wall from left abutment.

WILLIAMS LAKE DAM



5. View of spillway from downstream toe of dam -
note: debris and deteriorated condition.

Appendix D
Hydrologic and Hydraulic Computations

BY RFB DATE 10-6-80

LOUIS BERGER & ASSOCIATES INC.

SHEET NO. 1 OF CHKD. BY DATE PROJECT W-198SUBJECT WILLIAMS LAKEHydrology

FIND DRAINAGE AREA

SCALE: 1:24,000

READ #2	19.84
" #1	16.73
	<u>3.11</u>

READ #3	22.96
" #2	19.84
	<u>3.12</u>

AVE: 3.12

AREA = $3.12 \times 0.1435 = 0.45$ SQ. MI

RESERVOIR SURFACE AREA: ELEV. 434

READ #2	28.47
" #1	27.74
	<u>0.73</u>

READ #3	29.22
" #2	28.47
	<u>0.75</u>

AVE: 0.74

AREA = $0.74 \times 91.83 = 68$ ACRES

AREA ELEV 440

READ #2	30.20
" #1	29.35
	<u>0.85</u>

READ #3	31.04
" #2	30.20
	<u>0.84</u>

AVE: 0.84

AREA = $0.84 \times 91.83 = 77$ ACRES

AREA ELEV. 450

READ #2	31.56
" #1	30.56
	<u>1.00</u>

READ #3	32.61
" #2	31.56
	<u>1.05</u>

AVE: 1.02

AREA = $1.02 \times 91.83 = 94$ ACRES

BY RFB DATE 11-24-80 LOUIS BERGER & ASSOCIATES INC. SHEET NO. 2 OF
 CHKD. BY DATE PROJECT W-198
 SUBJECT WILLIAMS LAKE DAM STORAGE CAPACITY

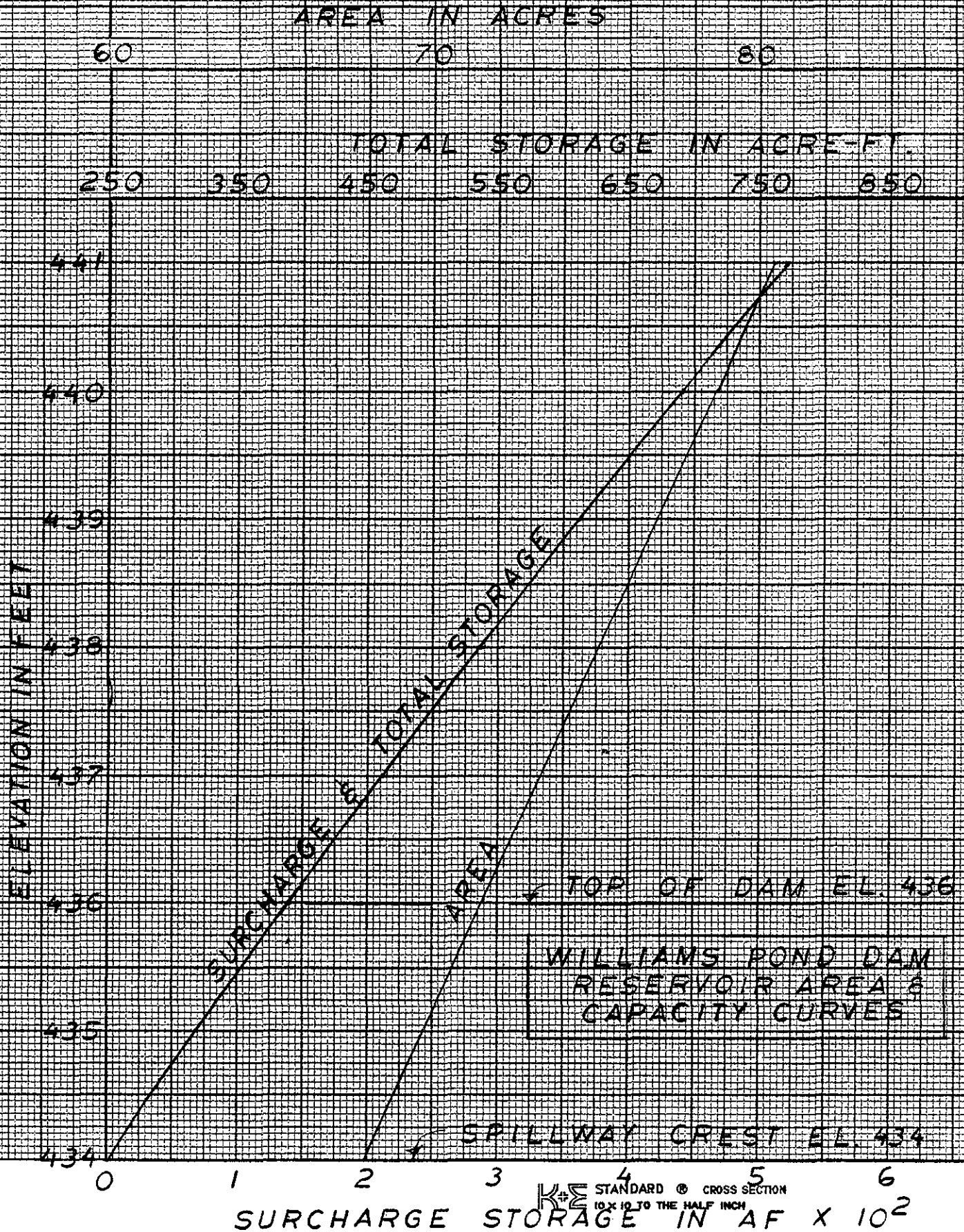
NORMAL STORAGE: FROM OWNER'S REPRESENTATIVES:
 LAKE IS ABOUT 10 FT DEEP

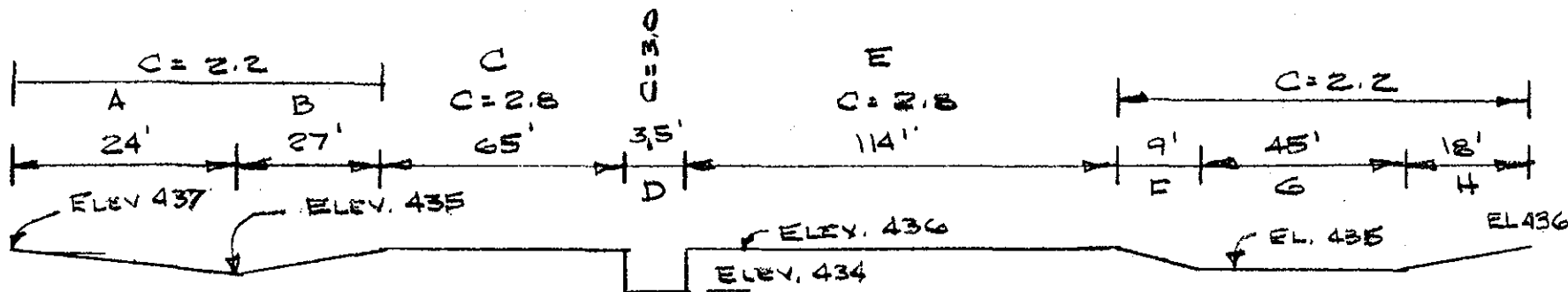
$$\text{STORAGE} = \frac{1}{2} hA = \frac{1}{2} 10 \text{ FT} (68A) \\ = 340 \text{ ACRE-FT}$$

FROM OLD COE INVENTORY: $S = 185 \text{ AF}$

SAY NORMAL STORAGE = 250 AF.
 @ ELEV. 434

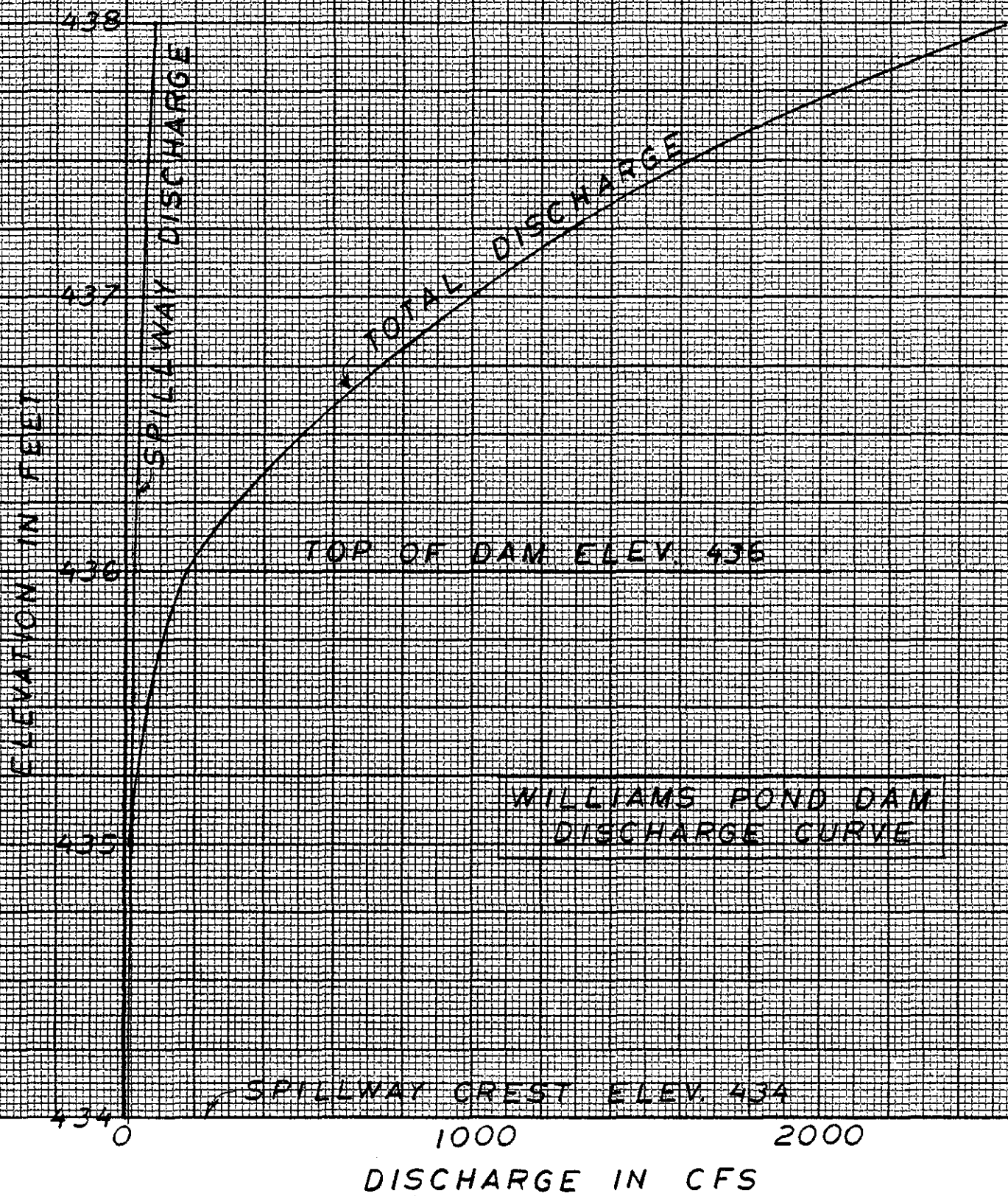
ELEV.	AREA ACRES	AVE. AREA	H	ΔV ACRE-FT	TOTAL STORAGE	SURCHARGE STORAGE
434	68				250	
435	69.8	68.9	1	68.9	319	69
436	71.6	70.7	↑	70.7	390	140
437	73.4	72.5		72.5	462	212
438	75.2	74.3		74.3	536	286
439	77	76.1		76.1	612	362
440	78.7	77.8		77.8	690	440
441	80.4	79.6	↑	79.6	770	520





ELEV.	A + B			C + E			D			F + G			G		
	H	L	Q	H	L	Q	H	L	Q	H	L	Q	H	L	Q
434	0	1	0	0	1	0	0	3.5	0	0	1	0	0	1	0
435	0	1	0	0	1	0	1	10	10	0	1	0	0	1	0
435.5	.25	19.5	5	0	1	0	1.5	19	19	.25	14	4	.5	45	35
436	.5	39	30	0	1	0	2	30	30	.5	27	21	1	1	99
436.5	.75	45	64	.5	179	177	2.5	42	42	.75	38	38	1.5	1	182
437	1	51	112	1	179	501	3	54	54	1	60	60	2	2	280
437.5	1.25	51	157	1.5	179	921	3.5	69	69	1.25	83	83	2.5	3	341
438	1.5	51	206	2	179	1418	4	84	84	1.5	109	109	3	3	514

ELEV.	Σ Q's
434	0
435	10
435.5	63
436	180
436.5	503
437	1007
437.5	1621
438	2331



DRAINAGE AREA = 0.45 sq. mi = 288 ACRES

RESERVOIR AREA = 68 ACRES < 25% D.A.

LENGTH OF LONGEST WATER PATH = 5,000 FT
L = 0.95 MILES

ELEVATION DIFFERENCE = 550 - 434 = 116 FT

$$\therefore \text{SLOPE} = \frac{116}{0.95} = 122 \text{ FT/MI} \quad \frac{1}{\sqrt{S}} = 11.05$$

$$\text{Now } \frac{LLC}{\sqrt{S}} = \frac{(0.95)(0.95)}{2(11.05)} = 0.041$$

$$\left(\frac{LLC}{\sqrt{S}} \right)^{0.33} = (0.041)^{0.33} = 0.348$$

$$LAG = K \left(\frac{LLC}{\sqrt{S}} \right)^{0.33} = K(0.348)$$

ASSUME K = 5.0 HRS

REFER TO "CURVE B" MOUNTAIN
REGION, MIXED TERRAIN,
SEE REG.

$$LAG = 5.0(0.348) = 1.74 \text{ HOURS}$$

$$T_p = 0.41D + 0.82 LAG, \text{ WHERE } D = 1.0 \text{ HRS}$$

$$T_p = 0.41(1) + 0.82(1.74)$$

$$T_p = 1.84 \text{ HRS}$$

CREEK VELOCITY

$$T_c = \frac{T_p - 0.5D}{0.6}$$

$$T_c = \frac{1.84 - 0.5}{0.6} = 2.23 \text{ HRS}$$

$$V = \frac{5000}{2.23 \times 3600} = 0.62 \text{ FT/SEC} \quad 0.1K$$

$$T_R = 1.67 T_P = 1.67 (1.84) = 3.07 \text{ HRS}$$

$$T_0 = T_P + T_R = 1.84 + 3.07 = 4.91 \text{ HRS}$$

Q_P = PEAK RATE IN CFS

$$Q_P = \frac{484 A Q}{T_P}$$

A = DRAINAGE AREA

Q = RAINFALL IN INCHS

$$Q_P = \frac{484 (0.45) (1)}{1.84} = 118 \text{ CFS}$$

PMP = PROBABLE MAXIMUM PRECIPITATION

$$= 25'' (0.8) = 20'' \text{ FOR MASSACHUSETTS}$$

$$= 19.6'' \text{ CONSIDERING INFILTRATION FOR OVERLAND FLOW.}$$

BY REB DATE 11-21-80 LOUIS BERGER & ASSOCIATES INC.

SHEET NO. 3 OF 3

CHKD. BY _____ DATE _____

PROJECT W-198

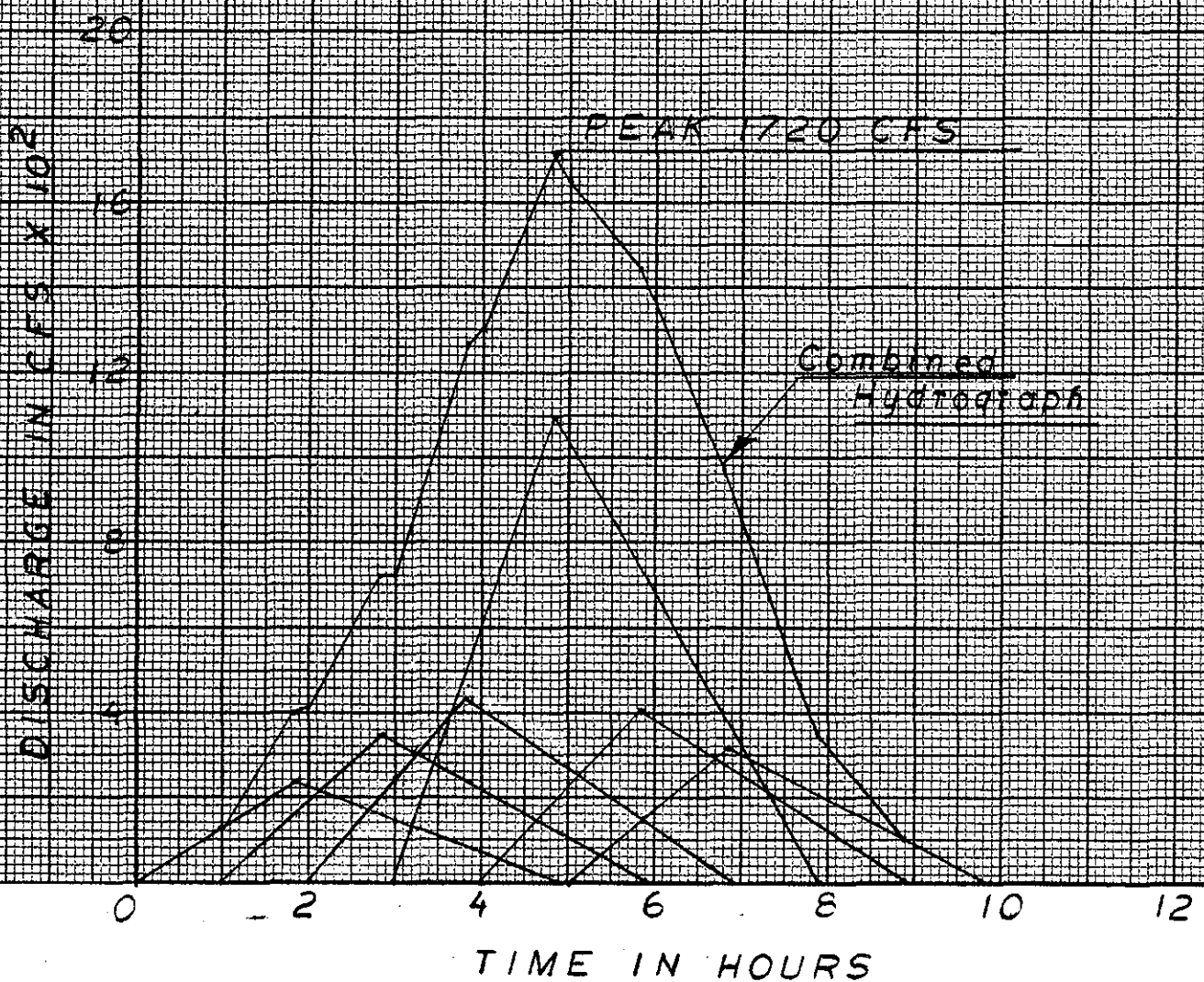
SUBJECT WILLIAMS LAKE DAM, INFLOW HYDROGRAPH

FLOOD HYDROGRAPH FOR PMF, $q_p = 118$ CFS

TIME (HOURS)	%	INCHS	Q _P CFS	BEGIN	PEAK	END
0.0	-					
1.0	10	1.96	231	0	1.84	4.91
2.0	12	2.35	345	1.0	2.84	5.91
3.0	15	2.94	432	2.0	3.84	6.91
4.0	38	7.45	1095	3.0	4.84	7.91
5.0	14	2.74	403	4.0	5.84	8.91
6.0	11	2.16	318	5.0	6.84	9.91

* DISTRIBUTION OF MAXIMUM 6 HOUR PMP
IN PERCENT OF 6 HOUR AMOUNT PER
EM 1110-2-141

WILLIAMS POND DAM
FULL PMF
INFLOW HYDROGRAPH



DRAINAGE AREA = 0.45 sq. mi = 288 ACRES

MAXIMUM STORAGE = 390 ACREE-FT.

HEIGHT = 6 FT.

∴ SIZE CLASSIFICATION = SMALL

HAZARD CLASSIFICATION = SIGNIFICANT

OCE GUIDELINES, USE 100 YR $\frac{1}{2}$ PMF

USE $\frac{1}{2}$ PMF FOR TEST FLOOD

FROM INFLOW HYDROGRAPH ∴ PMF = 1,720 CFS

TEST FLOOD = $\frac{1}{2}$ PMF = 860 CFS

STEP 1: $Q_{p1} = 860$ CFS

STEP 2a: STAGE = 436.87

STEP 2b: SURCHARGE VOLUME = 203 ACREE-FT

$$\text{INCHS RUNOFF} = \frac{203 \text{ A.F.}}{288 \text{ ACRES}} \times 12 = 8.45 \text{ IN.}$$

$$\text{STEP 2c: } Q_{p2} = 860 \left(1 - \frac{8.45}{9.5}\right)$$

$$Q_{p2} = 95 \text{ CFS}$$

STEP 3a: FOR $Q = 95$ CFS

SURCHARGE HEIGHT = 435.7

SURCHARGE VOL = 117 ACREE-FT

STEP 3a (CONTINUED)

$$\text{INCHS RUNOFF} = \frac{117 \times 12}{288} = 4.88 \text{ INCHS}$$

STEP 3b

$$\text{AVE STORAGE} = \frac{8.45 + 4.88}{2} = 6.665 \text{ IN.}$$

2ND ITERATION

$$\text{STEP 2c } Q_{P2} = 860 \left(1 - \frac{6.665}{9.5}\right)$$

$$Q_{P2} = 257 \text{ CFS}$$

$$\text{STEP 3a FOR } Q = 257 \text{ CFS}$$

$$\text{SURCHARGE HEIGHT} = 436.15$$

$$\text{SURCHARGE VOLUME} = 150 \text{ ACRE-FT.}$$

$$\text{INCHS RUNOFF} = \frac{150 \times 12}{288} = 6.25 \text{ INCHS}$$

$$\frac{\text{STOR}_1 + \text{STOR}_2}{2} = \frac{6.665 + 6.25}{2} = 6.46$$

3RD ITERATION

$$\text{STEP 2c } Q_{P2} = 860 \left(1 - \frac{6.46}{9.5}\right)$$

$$Q_{P2} = 275 \text{ CFS}$$

$$\text{STEP 3a FOR } Q = 275 \text{ CFS}$$

$$\text{SURCHARGE HEIGHT} = 436.175$$

STEP 3a (CONTINUED)

$$\text{SURCHARGE VOL} = 152 \text{ A.F.}$$

$$\text{INCHS RUNOFF} = \frac{152 \times 12}{288} = 6.33 \text{ IN.}$$

$$\text{STEP 3b } \overline{\text{STOR}} = \frac{6.46 + 6.33}{2} = 6.40 \text{ IN.}$$

$$\text{SURCHARGE VOL} = \frac{6.40 \times 288}{12} = 154 \text{ A.F.}$$

$$\text{SURCHARGE HEIGHT} = 436.2 \text{ FT.}$$

$$Q_{PD} = 290 \text{ CFS.}$$

$\frac{1}{2}$ PMF OVERTOPS SADDLES BY $436.2 - 435 = 1.2 \text{ FT}$

$\frac{1}{2}$ PMF OVERTOPS TOP OF DAM BY $436.2 - 436 = 0.2 \text{ FT.}$

$$Q_{OUT} = 290 \text{ CFS}$$

STEP 1: RESERVOIR ELEV. @ FAILURE = 436 FT

VOLUME RELEASED: $S_1 \approx 150 + 6/10(250) = 300 \text{ A.F.}$

HEIGHT = $Y_0 = 6 \text{ FT}$

$W = 40\% \text{ (LENGTH AT MID HEIGHT)} = 0.4(100) = 40 \text{ FT}$

STEP 2: PEAK FAILURE

$Q_{P1} = 0.27 W \sqrt{Y_0} Y_0^{3/2}$

$Q_{P1} = 1.68(40)(6)^{3/2}$

$Q_{P1} = 988 \text{ CFS}$

SPILLWAY $Q = 30 \text{ CFS}$, SADDLE $Q = 150$

TOTAL $Q_{P1} \approx 1140 \text{ CFS}$

REACH #1 DAM TO I-495 (L = 1400 FT)

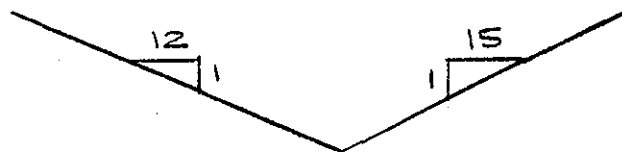
$Q = \frac{1.486}{n} A R^{2/3} S^{1/2}$

$Q = 2.39 A R^{2/3}$

$S = \frac{434 - 390}{1400} = 0.0314$

$S^{1/2} = 0.177$

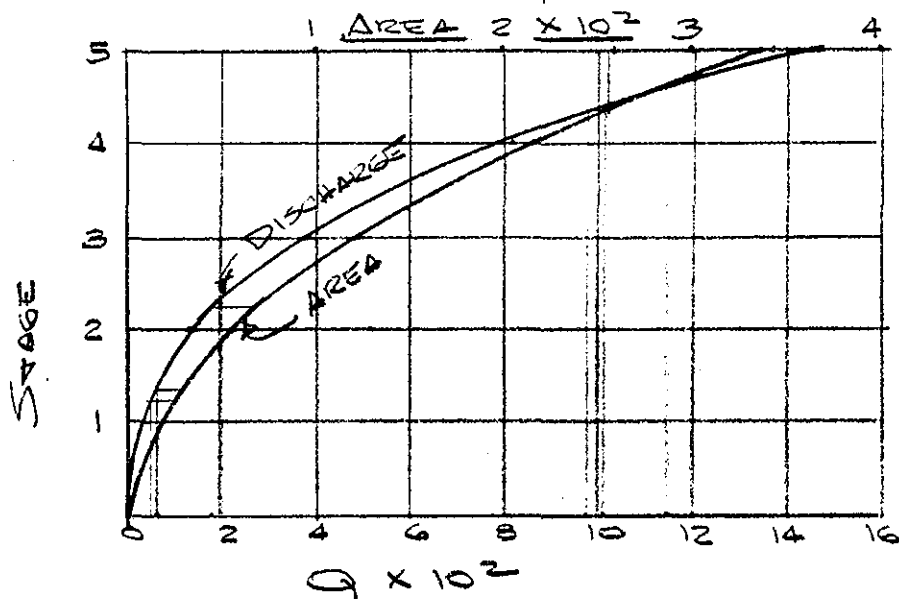
$n = .110$



STAGE	AREA	P	$R^{2/3}$	Q
2	54	54.15	1.0	129
3	122	81.22	1.31	382
4	216	108.30	1.58	816
5	338	135.4	1.84	1486

BY RFB DATE 11-24-80 LOUIS BERGER & ASSOCIATES INC.
 CHKD. BY _____ DATE _____
 SUBJECT WILLIAMS LAKE DAM , FAILURE ANALYSIS

SHEET NO. 2 OF 5
 PROJECT W-195



For $Q = 1140$, $STAGE = 4.6 \text{ FT.}$, $AREA = 288$
 " $Q = 180$, " = 68
 $\Delta A = 220$

$$V_1 = \frac{220 \times 1400}{43560} \approx 7 \text{ AF.}$$

$$Q_{P2} (\text{TRIAL}) = 1140 \left(1 - \frac{7}{300}\right)$$

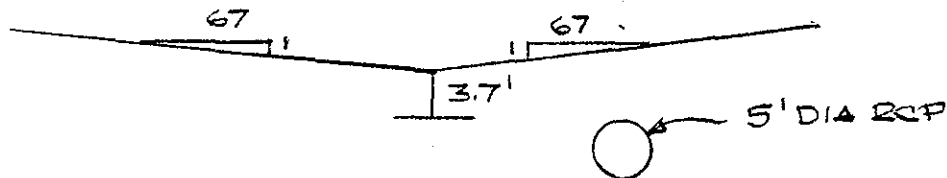
$$= 1110 \text{ CES}$$

For $Q = 1110$, $STAGE = 4.4 \text{ FT.}$, $AREA = 280$
 " $Q = 180$, " = 68
 $\Delta A = 212$

$$V_2 = \frac{212 \times 1400}{43560} \approx 7.0$$

$$V_{AVE} \approx 7 \text{ AF}$$

SAY $Q @ I-495 = 1110 \text{ CES}$



ROUTE I-495 CROSSING

HW	HW/D	Q PIPE	H	L	C	Q	Q TOTAL
3.05	0.61	60	0	0	0	0	60
8.7	1.74	260	0	0	0	0	260
10.7	2.14	300	1	268	2.5	670	970

* FROM F.H.A., HEC No. 5, CHART No. 2

Q = 970 CFS, OVERTOPS I-495 BY 2 FT +

REACH #2, I-495 TO GLEN ST. HOODSING DEVELOPMENT
L = 1300 FT.

$$S = \frac{390 - 350}{1300} = 0.0307$$

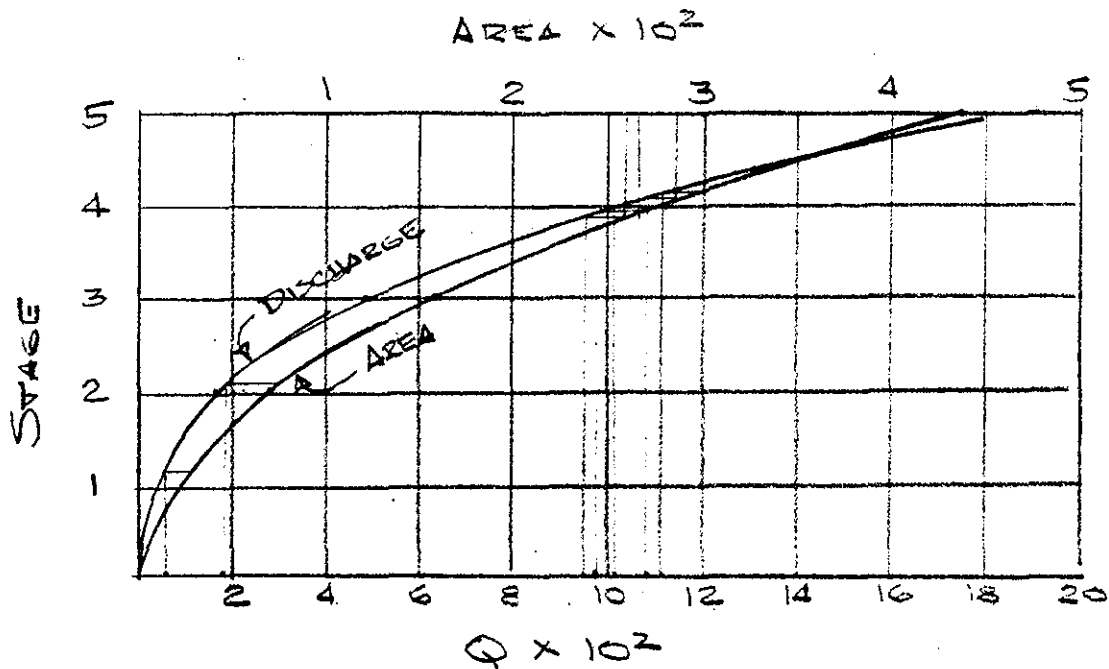
$$S^{1/2} = 0.175$$

$$n = 0.110$$



$$Q = \frac{1.486}{n} A R^{2/3} S^{1/2} = 2.36 A R^{2/3}$$

STAGE	AREA	P	R ^{2/3}	Q
2	70	70.12	1.0	165
3	158	105.17	1.31	488
4	280	140.24	1.58	1044
5	438	173.30	1.84	1900



For $Q = 1110$, $STAGE = 4.15$, $AREA = 300$
 " $Q = 180$ " $= 75$
 $\Delta A = 225$

$$V_1 = \frac{225 \times 1300}{43,560} = 7 \text{ A.F.}$$

$$Q_{P2} (\text{TRIAL}) = 1110 \left(1 - \frac{7}{300}\right)$$

$$= 1080 \text{ CFS}$$

For $Q = 1080$, $STAGE = 4.1$, $AREA = 275$
 " $Q = 180$ " $= 75$
 $\Delta A = 200$

$$V_2 = \frac{200 \times 1300}{43,560} = 6 \text{ AF}$$

$$V_{AVE} \approx 7 \text{ AF}$$

SAY Q @ GLEN ST HOUSING DEVELOPMENT = 1080

BY RFB DATE 11-25-80

LOUIS BERGER & ASSOCIATES INC.

SHEET NO. 5 OF 5

CHKD. BY _____ DATE _____

PROJECT _____

SUBJECT WILLIAMS LAKE DAM

FAILURE ANALYSIS

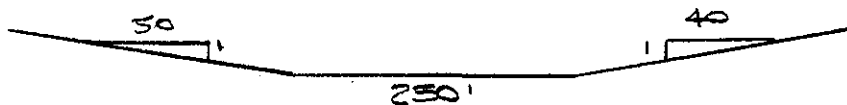
$$Q = \frac{1.486}{n} A R^{2/3} S^{1/2}$$

$$S = \frac{3}{1400} = .0036$$

$$Q = 1.19 A R^{2/3}$$

$$S^{1/2} = .060$$

$$n = .075$$



SECTION IN GLEN ST HOUSING DEVELOPMENT

STAGE	AREA	P	$R^{2/3}$	Q
1	295	340	0.91	320
1.5	476	385	1.15	651
2	680	430	1.35	1092

WATER WILL BE ABOUT 2 FT DEEP IN GLEN ST
HOUSING DEVELOPMENT, FLOODING ABOUT 20
HOMES IN BASEMENTS AND SEVERAL STREETS.

PREFAILURE STAGE \approx 0.5 FT

AREA OF
POTENTIAL FLOODING

**DRAINAGE
AREA**

WILLIAMS LAKE
DAM

LOUIS BERGER & ASSOC., INC
WELLESLEY, MASS.
ARCHITECT - ENGINEER

U.S. ARMY ENGINEER DIV. NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

WILLIAMS LAKE DAM

DRAINAGE AREA AND AREA OF POTENTIAL FLOODING

STATE - MA.

SCALE 1:25000

DATE

Appendix E

Information as Contained in the
National Inventory of Dams



INVENTORY OF DAMS IN THE UNITED STATES

STATE	IDENTITY NUMBER	DIVISION	STATE	COUNTY	CONGR. DIST.	STATE	COUNTY	CONGR. DIST.	NAME	LATITUDE (NORTH)	LONGITUDE (WEST)	REPORT DATE
												DAY MO YR
MA	451	NED	MA	017	03				WILLIAMS LAKE DAM	4220.2	7134.3	21 OCT 80

POPULAR NAME	NAME OF IMPOUNDMENT
	WILLIAMS LAKE

REGION	BASIN	RIVER OR STREAM	NEAREST DOWNSTREAM CITY-TOWN-VILLAGE	DIST FROM DAM (MI.)	POPULATION
01	09	MILLHAM BROOK	MARLBOROUGH	00	27900

TYPE OF DAM	YEAR COMPLETED	PURPOSES	STRUCT. HEIGHT (FT.)	HYDRAU. HEIGHT (FT.)	IMPOUNDING CAPACITIES		DIST	OWN	FED	R	PRV/FED	SCS	A	VER/DATE
					MAXIMUM (ACRE-FT.)	NORMAL (ACRE-FT.)								
HELOT	1882	S	6	6	320	250		NED	N	N	N	N		

REMARKS
21-STONEWALL DOWNSTREAM

D/S HAS	SPILLWAY			MAXIMUM DISCHARGE (FT.)	VOLUME OF DAM (CY)	POWER CAPACITY		NAVIGATION LOCKS									
	GUEST LENGTH	TYPE	WIDTH (FT.)			INSTALLED (MW)	PROPOSED (MW)	NO.	LENGTH (FT.)	WIDTH (FT.)	LENGTH (FT.)	WIDTH (FT.)	LENGTH (FT.)	WIDTH (FT.)			
1	183	U	4	30	790												

OWNER	ENGINEERING BY	CONSTRUCTION BY
CITY OF MARLBOROUGH	UNKNOWN	UNKNOWN

REGULATORY AGENCY			
DESIGN	CONSTRUCTION	OPERATION	MAINTENANCE
NONE	NONE	MA DEGE	MA DEGE

INSPECTION BY	INSPECTION DATE	AUTHORITY FOR INSPECTION
	DAY MO YR	
LOUIS BERGER & ASSOC INC	21 OCT 80	PL 92-367

REMARKS